MYCOTAXON
ISSN (print) 0093-4666 (online) 2154-8889 Mycotaxon, Ltd. ©2018
July–September 2018—Volume 133, pp. 387–395
https://doi.org/10.5248/133.387

New records of smut fungi from Korea. 3

Teodor T. Denchev[1*], Hyeon-Dong Shin[2], Cvetomir M. Denchev[1]

[1] *Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin St., 1113 Sofia, Bulgaria*
[2] *Division of Environmental Science and Ecological Engineering, Korea University, Seoul 02841, South Korea*
* Correspondence to: *ttdenchev@gmail.com*

Abstract—Four smut fungi, *Microbotryum nepalense, Sphacelotheca polygoni-senticosi, Tilletia barclayana,* and *T. setariae-viridis,* are reported for the first time from South Korea. Additionally, *Persicaria longiseta* and *P. posumbu* are newly recorded as South Korean hosts of *Sphacelotheca hydropiperis,* and *Echinochloa crus-galli* is a new South Korean host for *Ustilago trichophora.*

Key words—*Microbotryaceae, Poaceae, Polygonaceae,* taxonomy, *Tilletiaceae*

Introduction

As part of an ongoing study of smut fungi in South Korea (Denchev & Kakishima 2007; Denchev & al. 2007a, b, 2013; Park & al. 2010; Denchev & Denchev 2014), a taxonomic revision of specimens revealed four species new for this country: *Microbotryum nepalense, Sphacelotheca polygoni-senticosi, Tilletia barclayana,* and *T. setariae-viridis,* which are reported herein.

Materials & methods

Dried specimens from the Mycological Herbarium of Korea University, Seoul (KUS-F), College of Natural Sciences, Seoul National University, Seoul (SNU), and C.M. Denchev's personal collection (CMD) were examined under light microscope (LM) and scanning electron microscope (SEM). For LM observations and measurements, spores were mounted in lactoglycerol solution (w : la : gl = 1 : 1 : 2) on glass slides, gently heated to boiling point to rehydrate the spores, and then cooled.

The spore measurements are given as min–max (mean ± standard deviation). For SEM, spores were attached to specimen holders by double-sided adhesive tape and coated with platinum in a Hitachi E-1010 ion sputter. The surface structure of spores was observed and photographed at 15 kV accelerating voltage using a Hitachi S-3500N scanning electron microscope. The descriptions below are based entirely on the specimens examined. The list of shapes of spores is arranged in descending order of frequency.

Taxonomy

Microbotryum nepalense (Liro) Vánky, Mycotaxon 67: 47, 1998. FIGS 1, 2

SORI in the stem, fusiform, ≤5 cm long, usually in the upper part of the stem, most commonly closely below the intact inflorescence; initially covered by the epidermis that ruptures longitudinally exposing the semi-agglutinated, dark purple spore mass surrounding numerous vascular bundles. SPORES subglobose, broadly ellipsoidal, ellipsoidal, slightly irregular or ovoid, (9.5–)10–14.5(–15.5) × (9–)9.5–12.5(–13) µm (12.2 ± 1.0 × 10.8 ± 0.8 µm) (n = 100), medium reddish brown; spore wall evenly thickened, 0.7–1.0 µm thick, completely or often incompletely reticulate; meshes (8–)9–14(–16) per spore diameter, polyhedral or irregular, 0.4–1.5(–3.2) µm long; muri low, spore profile slightly affected. Immature spores abundant, intermixed with mature ones, hyaline to light purplish brown, usually smaller than the mature spores. In SEM spore wall reticulate, muri low, up to 0.2 µm high; the interspaces usually with 1–6 warts.

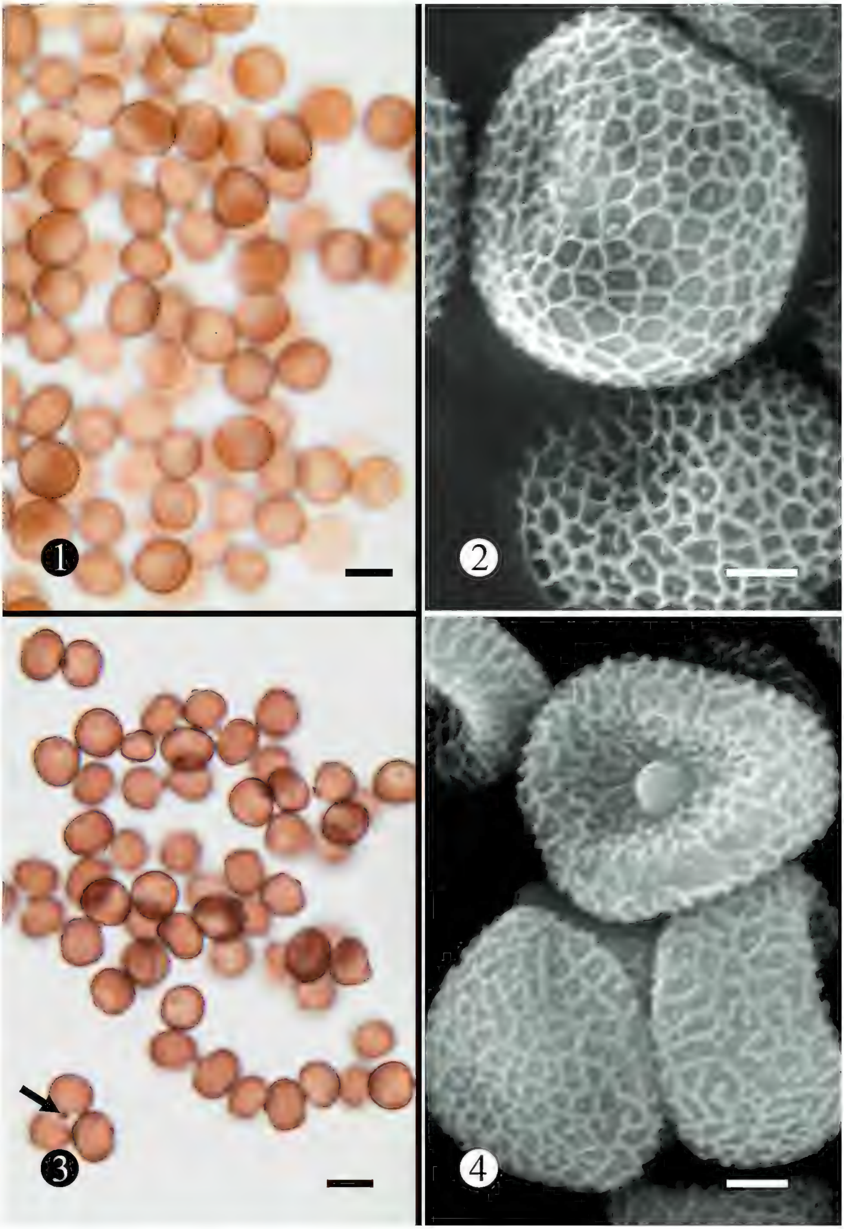
SPECIMEN EXAMINED—On *Persicaria nepalensis* (Meisn.) H. Gross: **SOUTH KOREA, GANGWON PROVINCE, Gangneung,** 28 October 1992, leg. H.D. Shin (KUS-F 12312).

COMMENTS—The morphological features of the examined specimen are similar to those reported by Kakishima & al. (2000) and Vánky (2011).

Microbotryum nepalense is known from Asia (Tadzhikistan, Pakistan, India, Nepal, China, Russian Far East, and Japan) and East Africa (Ethiopia) (Ahmad 1956; Kakishima 1982; Karatygin & Azbukina 1989; Kakishima & Ono 1993; Azbukina & al. 1995; Guo 2000; Kakishima & al. 2000; Vánky 2005, 2007; Vánky & al. 2011; Denchev & Denchev 2017). *Persicaria nepalensis* is the only known host plant of this smut fungus.

Sphacelotheca polygoni-senticosi S. Ito, Trans. Sapporo Nat. Hist. Soc. 14: 90, 1935. FIGS 3, 4

SORI in some ovaries of an inflorescence, swollen, 3.5–6.5 mm long, covered by a thick, brittle, yellow-brown peridium that later ruptures irregularly from the apex, exposing powdery, very dark reddish brown mass of spores,



Figs 1–4. ***Microbotryum nepalense*** on *Persicaria nepalensis* (KUS-F 12312). 1. Spores in LM. 2. Spores in SEM. ***Sphacelotheca polygoni-senticosi*** on *Persicaria senticosa* (KUS-F 10409). 3. Spores in LM (arrow shows spores connected by a disjunctor). 4. Spores in SEM. Scale bars: 1, 3 = 10 µm; 2, 4 = 2 µm.

surrounding a stout columella. Spores often more or less flattened, in plane view suborbicular, slightly irregular, orbicular or broadly elliptical, in plane view (9–)9.5–12(–13) × (8.5–)9–11.5(–12) µm (10.6 ± 0.6 × 10.2 ± 0.5 µm) (n = 100), middle purplish brown, initially in chains, connected by disjunctors, later single, with 2(–3), persistent appendages representing remnants of disjunctors; wall evenly thickened, 0.6–0.9 µm thick. In SEM the majority of warts variously interconnected, forming a labyrinthiform or incompletely reticulate surface pattern.

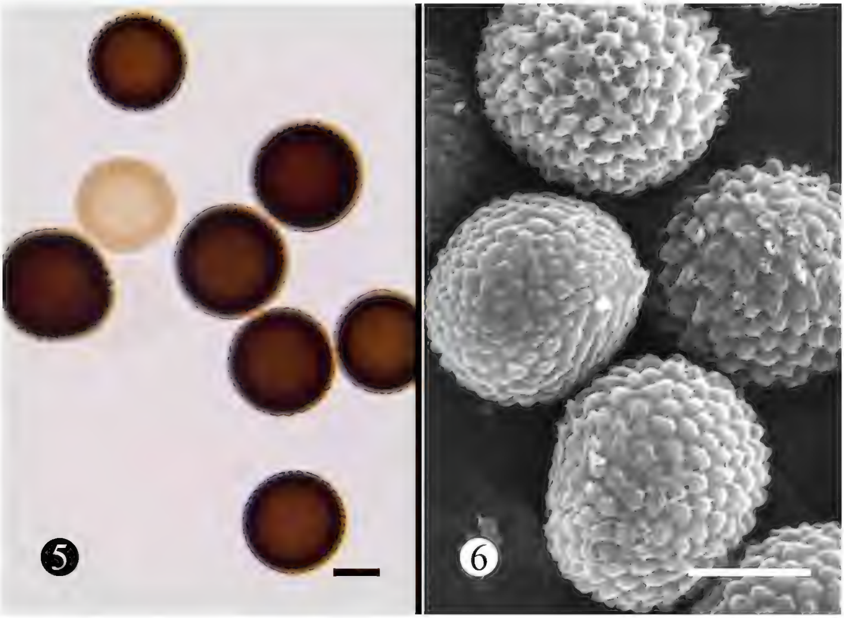
Specimens examined—On *Persicaria senticosa* (Meisn.) H. Gross ex Nakai: **SOUTH KOREA, Gangwon Province, Yangku,** 7 June 1998, leg. H.D. Shin (KUS-F 14613); **Chuncheon,** 27 September 1997, leg. H.D. Shin (KUS-F 14271); 19 August 1998, leg. H.D. Shin (KUS-F 14847); 21 August 2001, leg. H.D. Shin (KUS-F 18262); 17 September 2001, leg. H.D. Shin (KUS-F 18421); 11 October 2002, leg. H.D. Shin (KUS-F 19213); **Gangneung,** 15 September 1990, leg. H.D. Shin (KUS-F 10409); 7 August 1993, leg. H.D. Shin (KUS-F 12506); **Hoengseong,** 11 October 2004, leg. H.D. Shin (KUS-F 20836); **Wonju,** 17 September 1999, leg. H.D. Shin (KUS-F 16749). **Gyeonggi Province, Mt. Hwaya,** Cheolgol Valley, alt. 160 m, 15 September 1996, leg. S.T. Kim (SNU 86594); **Gwangju,** 10 June 1972, sine coll. (SNU s.n.). **Jeollanam Province, Kurye,** Mt. Chiri at Hwaom Temple, 2 October 1999, leg. C.W. Park & J.H. Park (SNU 92095). **Jeju Province,** Jeju, 31 October 2002, leg. H.D. Shin (KUS-F 19325).

Comments—Vánky & Oberwinkler (1994) and Vánky (2011) treated *S. polygoni-senticosi* as a synonym of *S. hydropiperis,* but we recognize it as a distinct species. The taxonomic status of *S. polygoni-senticosi* will be discussed in a separate article. The morphological description of *S. polygoni-senticosi,* given by Ito (1935, 1936), lacks information currently considered as essential for interpretation of *Sphacelotheca* species, but the morphological features of the examined Korean specimen match very well those of the holotype specimen, studied by us.

As a distinct species, *S. polygoni-senticosi* has been previously reported from Japan (Yoshinaga 1901, as *Ustilago polygoni-senticosi;* Ito 1935, 1936), Taiwan (Sawada 1944), and China (Guo 1992, Kakishima & al. 2000).

Tilletia barclayana (Bref.) Sacc. & P. Syd., Syll. Fung. 14: 422, 1899. Figs 5, 6

Sori in some swollen ovaries of an infected plant, ovoid, 4–6 mm long, with a short, acute tip, bearing a rudimentary style and stigmas, covered by a thick, initially greenish, later yellow-brown pericarp that ruptures from its apex exposing a powdery, blackish brown mass of spores and sterile cells. Sterile cells variable in shape, size, and wall thickness, subglobose, globose, broadly ellipsoidal or irregular, 11–27 µm long, hyaline or subhyaline; cell wall 1.6–3.5 µm thick, sometimes indistinctly laminate, occasionally with a narrow appendage.



Figs 5, 6. *Tilletia barclayana* on *Pennisetum alopecuroides* (KUS-F 10405). 5. Spores in LM. 6. Spores in SEM. Scale bars = 10 µm.

Spores globose, subglobose or broadly ellipsoidal, (20.5–)21.5–29(–30.5) × (19–)20–26.5(–28.5) µm (24.2 ± 1.8 × 23.4 ± 1.7 µm) (n = 100), middle to very dark reddish brown; spore wall (2.6–)2.8–3.7(–4.0) µm thick (including the 0.8–1.8(–2.2) µm high ornamentation), papillate; papillae (30–)32–42(–44) on equatorial circumference, in surface view solitary or appearing aggregated (seen as irregular, darker areas). In SEM papillae connected with low, fine ribs.

Specimens examined—On *Pennisetum alopecuroides* (L.) Spreng.: **SOUTH KOREA, Gangwon Province, Goseong,** 27 August 2001, leg. H.D. Shin (KUS-F 18300); **Gangneung,** 15 September 1990, leg. H.D. Shin (KUS-F 10405). **Incheon Metropolitan City, Ganghwa Island,** 28 September 1999, leg. H.D. Shin (KUS-F 16834).

Comments—The morphological features of the examined specimens are similar to those reported by Vánky (2011).

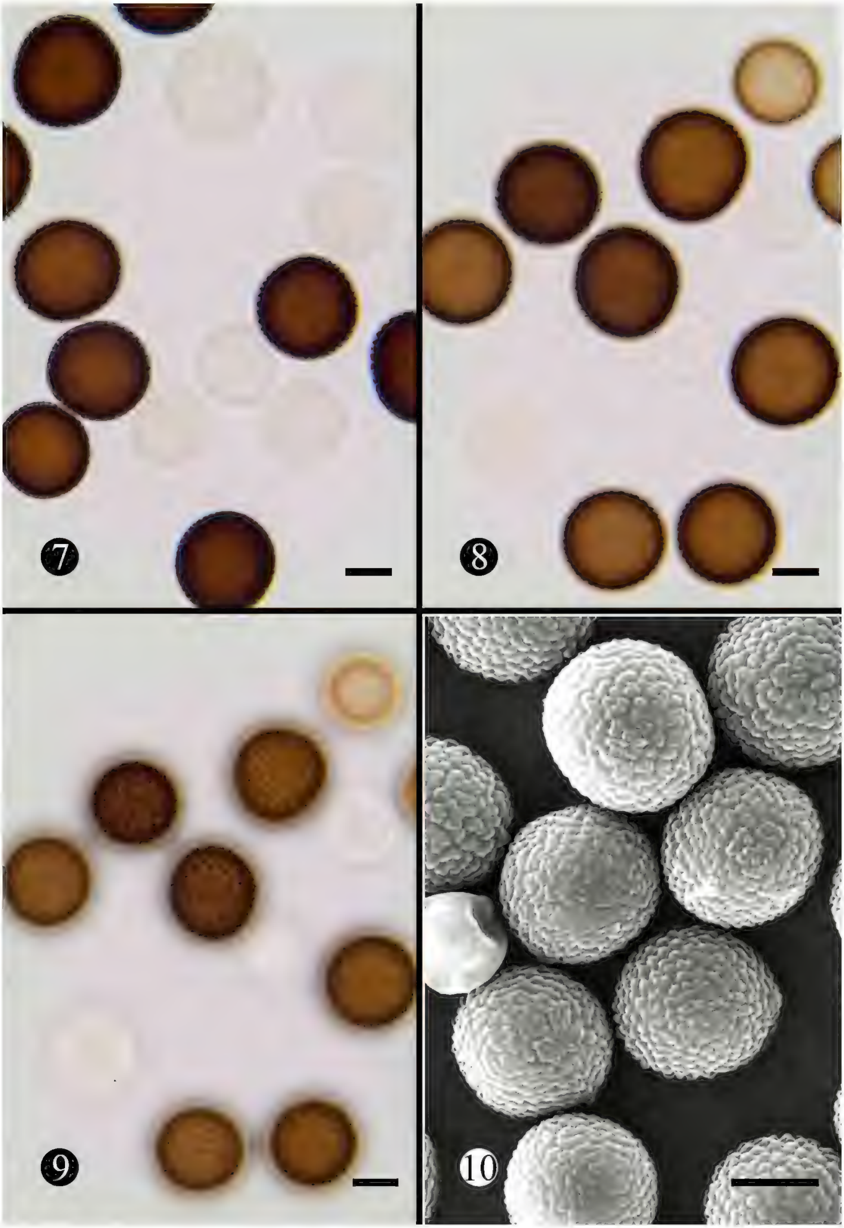
An inner layer of the spore wall, that is 0.7–1.1 µm thick, can be observed in the lightly colored, immature spores. *Tilletia barclayana* is known on *Pennisetum* spp. from Asia and North America (Vánky 2011).

Tilletia setariae-viridis Vánky, Mycotaxon 78: 316, 2001. FIGS 8–10

SORI in some swollen ovaries of an infected plant, exceeding the floral bracts, ovoid or ellipsoid, 2.5–4.5 mm long, sometimes bearing rudimentary stigmas, covered by a thick, initially greenish, later yellow-brown or purplish brown pericarp that ruptures from its apex exposing a powdery, blackish mass of spores and sterile cells. STERILE CELLS subglobose, slightly irregularly rounded or broadly ellipsoidal, (9.5–)11–23(–24) × (9.5–)10.5–22(–23) µm, hyaline; cell wall two-layered or indistinctly laminate, (1.2–)1.4–2.6(–3.0) µm thick, sometimes with a narrow appendage, in SEM punctate. SPORES globose, subglobose or broadly ellipsoidal, (21.5–)22–27(–28) × (20–)21–25(–26) µm (24.4 ± 1.3 × 23.2 ± 1.2 µm) (n = 100), medium or dark reddish brown; spore wall (2.9–)3.1–3.6(–3.8) µm thick (including the 0.7–1.2(–1.4) µm high ornamentation and the hardly visible, 0.7–1.0 µm thick inner layer), papillate, occasionally with a narrow, hyaline appendage; papillae in surface view often appearing aggregated (seen as irregular, darker areas; FIG. 9). In SEM papillae connected with low, fine ribs.

SPECIMENS EXAMINED—On *Setaria viridis* (L.) P. Beauv.: **SOUTH KOREA, GANGWON PROVINCE,** near **Seom River,** near Hoengseong Recreational Forest near Hoengseong town, 37°32′31″N 128°06′25″E, 8 September 2006, C.M. Denchev 06-23 (CMD); **Hoengseong Recreational Forest** near Hoengseong town, 37°32′13″N 128°06′57″E, 8 September 2006, C.M. Denchev 06-25 (CMD); **Mt. Chiak** near Wonju city, 37°23′58″N 128°02′59″E, 15 September 2006, C.M. Denchev 06-16 (CMD). — **CHINA, BEIJING,** 39°46′ N, 116°20′ E, alt. c. 50 m, 22 September 1979, Z.Y. Zhao & al. (isotype, Vánky, Ustilag. Exsic. no. 292, as *T. setariae*).

COMMENTS—The above description of *Tilletia setariae-viridis* is based on the examined South Korean specimens. An isotype of *T. setariae-viridis* was also studied, as a comparative specimen (FIG. 7). The spore sizes of the Korean specimens are similar to those of the isotype, which measured (20–) 21.5–27(–28) × (20–)21–25(–26) µm (23.3 ± 1.4 × 22.2 ± 1.1 µm) (n = 100). Although the spore colour of *T. setariae-viridis* is given in its protologue (Vánky 2001) as yellowish brown, it is in fact medium or dark reddish brown. In the protologue, the spore wall thickness is measured without considering the thickness of the inner layer. The spore wall thickness of the Korean specimens is similar to that of the examined isotype. The protologue cites the height of the spore wall ornaments as 1.5–2.5 µm, but in the isotype they measured 0.6–1.2 µm, which matches that of the Korean specimens. The sterile cell sizes of the isotype are similar to those of the Korean specimens. The single sterile cells longer than 30 µm observed in both isotype and Korean specimens were considered aberrant and not included in the length range.



FIGS 7–10. *Tilletia setariae-viridis* on *Setaria viridis*. 7. Spores in LM (isotype, Vánky, Ustilag. Exsic., no. 292). 8, 9. Spores in LM (8 = median view; 9 = surface view; CMD 06-23). 10. Spores in SEM (CMD 06-23). Scale bars = 10 µm.

Tilletia setariae-viridis has been previously known only from China (Vánky 2001, 2011; Guo 2011).

Sphacelotheca hydropiperis (Schumach.) de Bary,
Vergl. Morph. Biol. Pilze: 187, 1884.

Specimens examined—On *Persicaria longiseta* (Bruijn) Kitag.: **SOUTH KOREA, Gangwon Province, Hoengseong,** 11 October 2004, leg. H.D. Shin (KUS-F 20835, host as *P. blumei*).

On *Persicaria posumbu* (Buch.-Ham. ex D. Don) H. Gross: **SOUTH KOREA, Gangwon Province, Hongcheon,** 1 October 2003, leg. H.D. Shin (KUS-F 19778, host as *P. posumbu* var. *laxiflora*); **Jeongseon,** 16 October 2000, leg. H.D. Shin (KUS-F 17847, host plant as *P. posumbu* var. *laxiflora*).

Comments—*Persicaria longiseta* and *P. posumbu* are new South Korean hosts of *Sphacelotheca hydropiperis.*

Ustilago trichophora (Link) Körn., Hedwigia 16: 36, 1877.

Specimen examined—On *Echinochloa crus-galli* (L.) P. Beauv.: **SOUTH KOREA, Gangwon Province, Yangku,** 28 September 1996, leg. H.D. Shin (KUS-F 13693).

Comments—*Echinochloa crus-galli* is a new South Korean host of *Ustilago trichophora;* the smut has been previously reported from South Korea only on *E. frumentacea* Link (as *E. crus-galli* var. *frumentacea;* Cho & Shin 2004).

Acknowledgements

This study was supported by the Korea Research Foundation and the Korean Federation of Science and Technology Societies Grant funded by Korea Government (MOEHRD, Basic Research Promotion Fund). The authors gratefully acknowledge Dr Eric H.C. McKenzie (Manaaki Whenua Landcare Research, Auckland, New Zealand) and Dr Makoto Kakishima (University of Tsukuba, Tsukuba, Japan, and Jilin Agricultural University, Changchun, China) for critically reading the manuscript and serving as pre-submission reviewers, and Director and Curator of SNU (Herbarium of College of Natural Sciences, Seoul National University) for granting access to the collections.

Literature cited

Ahmad S. 1956. Fungi of West Pakistan. Biological Society of Pakistan. Monograph No. 1. Lahore, Pakistan.

Azbukina ZM, Karatygin IV, Govorova, OK. 1995. *Ustomycetes* Moore. 9–205, in: ZM Azbukina (ed.), Plantae non vasculares, *Fungi* et *Bryopsida* orientis extremi rossica, Fungi, 3. Nauka, St. Petersburg. [In Russian]

Cho WD, Shin HD. 2004. List of plant diseases in Korea. Fourth edition. The Korean Society of Plant Pathology, Seoul.

Denchev TT, Denchev CM. 2014. The genus *Moreaua* in Japan and Korea. Mycotaxon 127: 73–80. https://doi.org/10.5248/127.73

Denchev TT, Denchev CM. 2017. Contributions to the smut fungi of Africa. 3. First record of *Microbotryum polygoni-alati.* Mycobiota 7: 19–24. https://doi.org/10.12664/mycobiota.2017.07.04

Denchev CM, Kakishima M. 2007. Notes on some Japanese smut fungi. IV. *Mundkurella japonica,* sp. nov. Mycotaxon 102: 9–16.

Denchev CM, Choi YJ, Lee SK, Shin HD. 2007a. New records of smut fungi from Korea. 1. Mycotaxon 100: 67–72.

Denchev CM, Shin HD, Kim SM. 2007b. New records of smut fungi from Korea. 2. Mycotaxon 100: 73–78.

Denchev TT, Denchev CM, Michikawa M, Kakishima M. 2013. The genus *Anthracoidea* (*Anthracoideaceae*) in Japan and some adjacent regions. Mycobiota 2. 125 p. https://doi.org/10.12664/mycobiota.2013.02.01

Guo L. 1992. Five species of *Ustilaginales* new to China. Mycosystema 5: 155–163.

Guo L. 2000. Flora Fungorum Sinicorum. Vol. 12. *Ustilaginaceae.* Science Press, Beijing. [In Chinese]

Guo L. 2011. Flora Fungorum Sinicorum. Vol. 39. *Tilletiales, Urocystidales, Entorrhizales, Doassansiales, Entylomatales, Georgefischeriales.* Science Press, Beijing. [In Chinese]

Ito S. 1935. Notae micologicae Asiae orientalis. II. Transactions of the Sapporo Natural History Society 14: 87–96.

Ito S. 1936. *Ustilaginales.* 1–148, in: Mycological flora of Japan, vol. 2, *Basidiomycetes,* no. 1. Yokendo, Tokyo. [In Japanese]

Kakishima M. 1982. A taxonomic study on the *Ustilaginales* in Japan. Memoirs of Institute of Agriculture and Forestry, University of Tsukuba (Agricultural and Forestry Science) 1: 1–124. [In Japanese]

Kakishima M, Ono Y. 1993. Smut fungi (*Ustilaginales*) collected in Pakistan. 187–214, in: T Nakaike, S Malik (eds), Cryptogamic flora of Pakistan, 2. National Science Museum, Tokyo.

Kakishima M, Denchev CM, Zhou X, Zang M. 2000. Smut fungi from Yunnan Province, China, collected in 1998. Bulletin of the National Science Museum, Tokyo, Series B (Botany) 26(1): 23–34.

Karatygin IV, Azbukina ZM. 1989. Definitorium fungorum URSS. Ordo *Ustilaginales.* Fasc. 1. Familia *Ustilaginaceae.* Nauka, Leningrad. [In Russian]

Park M-J, Denchev CM, Han K-S, Shin H.-D. 2010. Occurrence of *Rhamphospora nymphaeae* on *Nymphaea tetragona* in Korea. Plant Pathology Journal 26: 293. https://doi.org/10.5423/PPJ.2010.26.3.293

Sawada K. 1944. Descriptive catalogue of the Formosan fungi. Part X. Report of the Department of Agriculture Government Research Institute of Formosa 87: 1–96 + Plates I–V. [In Japanese]

Vánky K. 2001. Taxonomical studies on *Ustilaginales.* XXI. Mycotaxon 78: 265–326.

Vánky K. 2005. The smut fungi of Ethiopia and Erithrea. Lidia 6: 93–120.

Vánky K. 2007. Smut fungi of the Indian Subcontinent. Polish Botanical Studies 26. 265 p.

Vánky K. 2011 ["2012"]. Smut fungi of the world. APS Press, St. Paul, Minnesota, USA.

Vánky K, Oberwinkler F. 1994. *Ustilaginales* on *Polygonaceae* – a taxonomic revision. Nova Hedwigia, Beiheft 107. 96 p.

Vánky K, Vánky C, Denchev CM. 2011. Smut fungi in Africa – a checklist. Mycologia Balcanica 8: 1–77.

Yoshinaga T. 1901. On some fungi from Tosa. Botanical Magazine (Tokyo) 15: 94–98. [In Japanese] https://doi.org/10.15281/jplantres1887.15.171_94